Eastern and Southern Africa Partnership Programme (ESAPP)

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NRM3

Water Abstractions Monitoring Campaign for

Naro Moru
Sirimon

Rivers

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Water Abstractions Monitoring Campaign for the Sirimon River, Upper Ewaso Ngiro North Basin.

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Final Report

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LIST OF ACRONYMS AND ABBREVIATIONS

AEZ-	Agro-Ecological Zones
CDE-	Centre for Development and Environment, Institute of Geography, Unversity of Bern Switzerland.
CETRAD-	Centre for Training and Integrated Research for ASAL Development.
DWR-	Department of Water Resources
FAO-	Food and Agricultural Organization.
FF-	Flood Flow
KARI-	Kenya Agricultural Research Institute.
LRP-	Laikipia Research Project.
MoWD-	Ministry of Water Development
NF-	Normal Flow
NRM3 –	Natural Resources Monitoring, Modelling and Management
RF-	Rural Focus.
RGS –	River Gauging Station
RWUA –	River Water Users Associations
UENNB-	Upper Ewaso Ngiro North Basin

Purpose

This document is intended to provide some basic information on the water availability, apportionment and utilization within the Sirimon River Catchment. It should assist interested people and stake holders gain a knowledge on the water resources situation a first step in the preparation of water management plans and is a continuation of our initiative to support proper development and enhancement of the functionality of Water User Associations. Over utilization of river water resources is a major problem in this catchment and the role of a RWUA is highlighted in terms of recommendations aimed at improving river water resources assessment and management. Data collected in a snapshot campaign, NRM3 hydrology and abstraction permits database as well as records of the Water Department.

By undertaking this monitoring exercise, we look forward to assisting in the following areas of water resources management through supporting the Sirimon River Water Users Association.

i). Use of up to-date information on water resources in meetings, analysis and discussions with participation of all the stakeholders and establishing water use efficiency
ii). Attaching importance to water resources monitoring both in terms of quality and quantity.
iii). Improvement of equity of water use especially between upstream and downstream users to control the often observed increased water scarcity as one moves downstream.
iv). Enhancing the wider public awareness on the need and methods of dealing with water related problems and all aspects of water management.
v). Strengthening of self-regulatory measures and mechanisms through strong community participation and a clear understanding of how to go about the monitoring requirements to supplement the Water Department's work.
vi). Creating an understanding of other peoples needs and hence change attitudes and perception of sharing of water resources
vii). Promoting of an integrated approach to water development in the region where the water users play an active role in its conservation and wise use while without ignoring other related developmental and environmental issues..
viii). Utilization of management strategies based on the changing land use systems in their area of jurisdiction.

The documentation exercise therefore follows recommendations from various stake holders including users of the Sirimon River. It has been carried out with participation from the following organizations:

Natural Resources Monitoring Modelling and Management (NRM3)
Water Department Office, Nanyuki and Nyeri
Divisional Water Office, Sirimon (RWUA)

The preparations and Inventory team comprised of the following:

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1 Background Information for the Inventory Area

1.1 Catchment Description

Sirimon is a small subcatchment with a drainage area of 76.5km2 located on the South Eastern side of the Ewaso Ng'iro catchment. It has one perennial river and a few ephemeral streams that have water only during the rainy season. The subcatchment has a total length of 41.6km and an average width of 2.1 km. (Figure 1).

The subcatchment originates from the northern slopes of mount Kenya and slopes down to end on the lowland plains where the river meets with river Kongoni. The upper part of the subcatchment is rugged and forested. The river passes through deep river valleys that have resulted from years of riverbank erosion. The stream flood plain is averaged at 8.8m wide.

This area is administratively shared between two districts and two provinces. 75% is in Meru (Eastern Province) and the remaining is in Laikipia (Rift Valley Province).

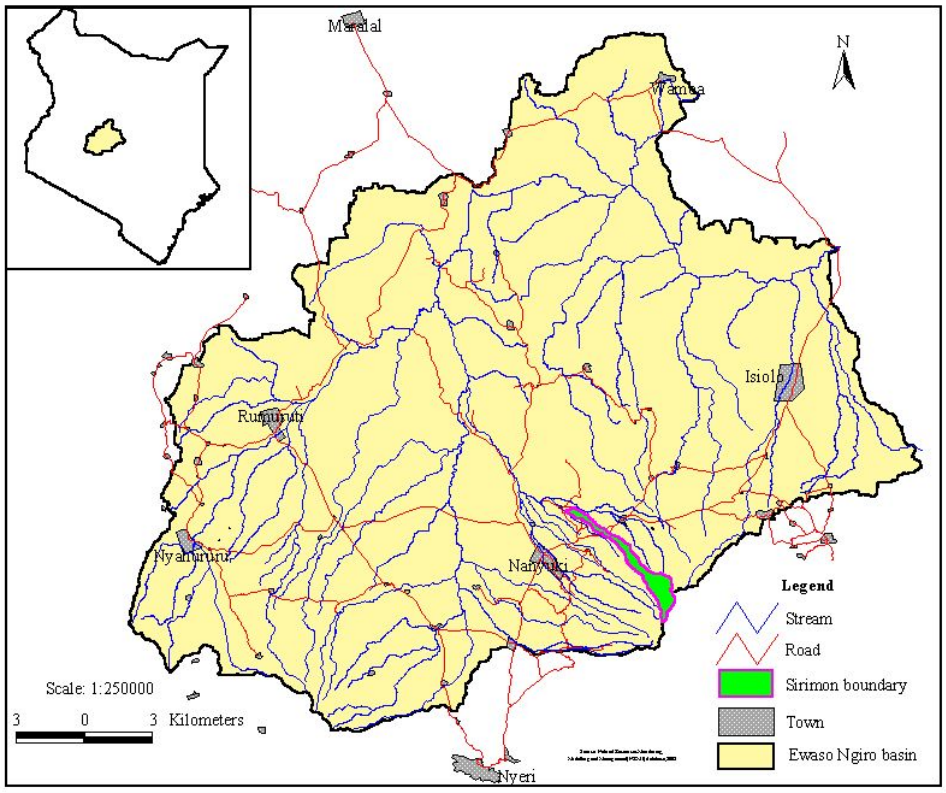


Figure 1: General Map of the Sirimon Catchment Area Showing its Location Within the Upper Ewaso Ngiro North Basin

1.2 CLIMATE AND HYDROLOGY

1.2.1 Climate

The catchment originates from the Mount Kenya with a cool wet climate and flows down to the Laikipia Plateau which is characterized by a semi arid climate. The altitude ranges from 4470 m.a.s.l in the upper parts of the sub-catchment to 1880 m.a.s.l at the outlet (**Figure 2**). The slope ranges between 14% and 4% with the steeper slopes been found on the higher slopes of Mount Kenya as seen in the elevation map.

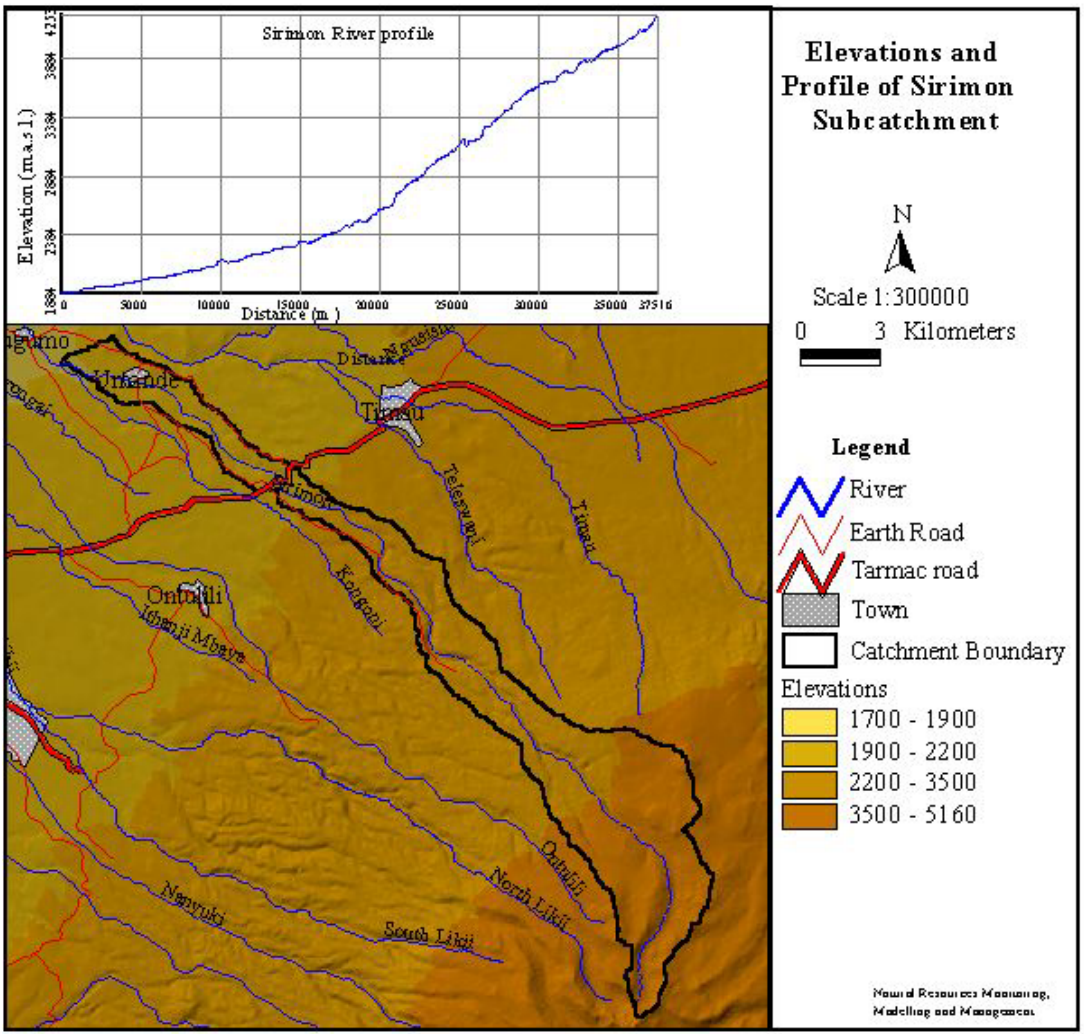


Figure 2: Elevations and Profile of Sirimon catchment

The monthly mean temperatures range between 7.6 ^{o}C in the high cooler areas to 22 ^{o}C at the lower parts (Berger, P. 1989). This catchment has a rapid highland to lowland climatic change with the larger part being a semi-arid environment. Exploitation of this perennial river, has been increasing with time as the demand for water increases resulting in poor water availability during the dry season.

The Sirimon catchment lies within the agro climatic zones (AEZ) I to V. It is also characterized by low amount as shown in Figure 3. The low rainfall can be attributed to the fact that the catchment is located on the leeward side of Mt. Kenya. The distribution of this bimodal low rainfall amounts is highly skewed with the highest both in depth and intensity received in the upper forested zone (Liniger, 1995; Sturm, 2001). The distribution of the total annual rainfall over the catchment is shown in Figure 3.

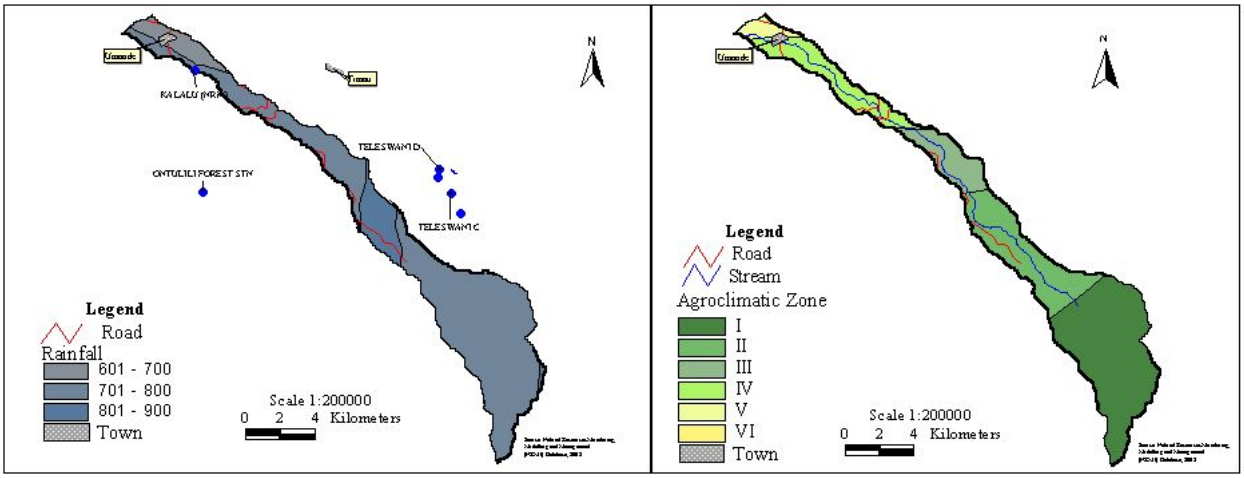


Figure 3: Rainfall and Agro-climatic pattern in Sirimon

Figure 4 shows the mean, maximum and minimum annual rainfall for the rainfall stations in the catchment.

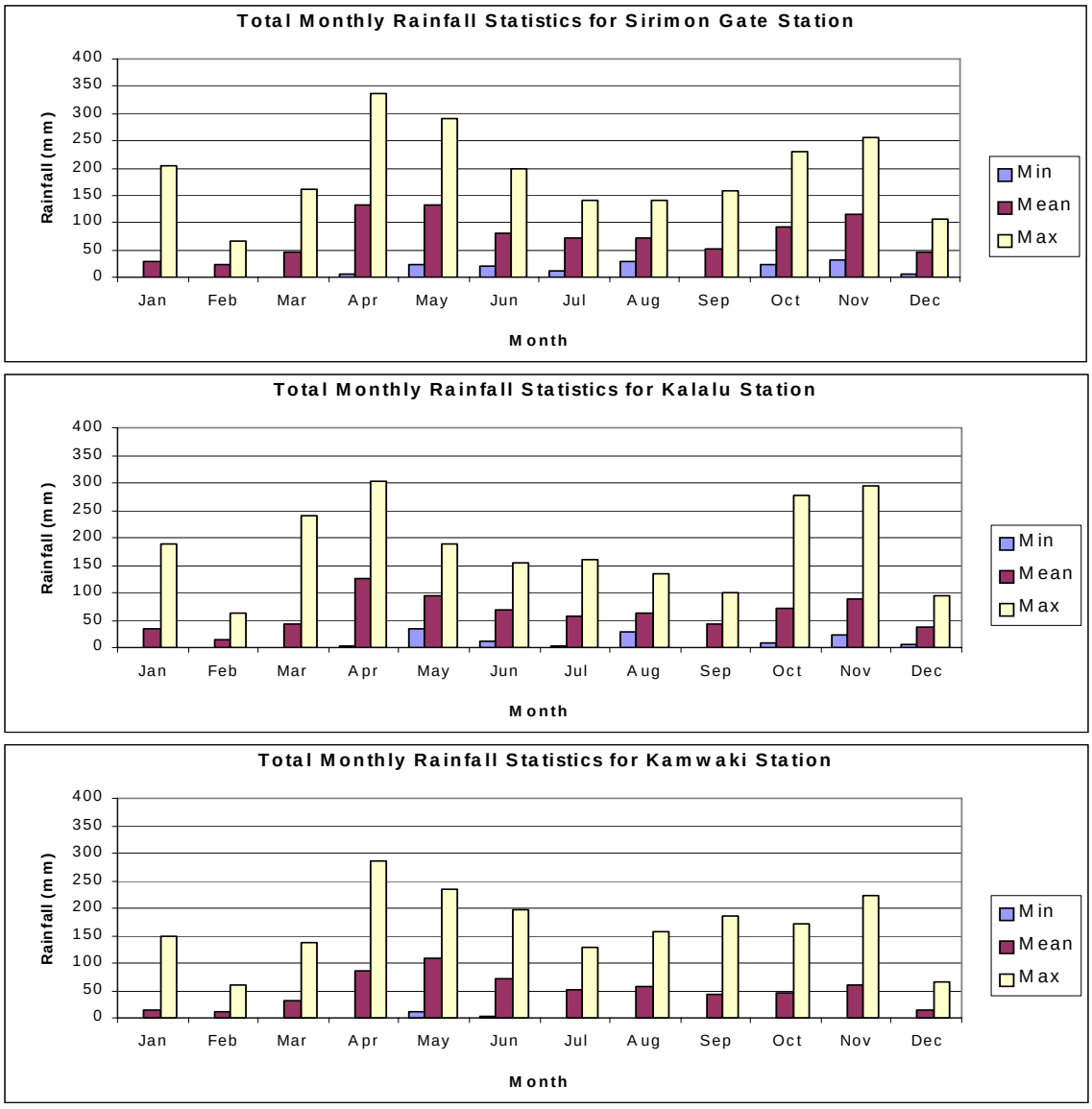


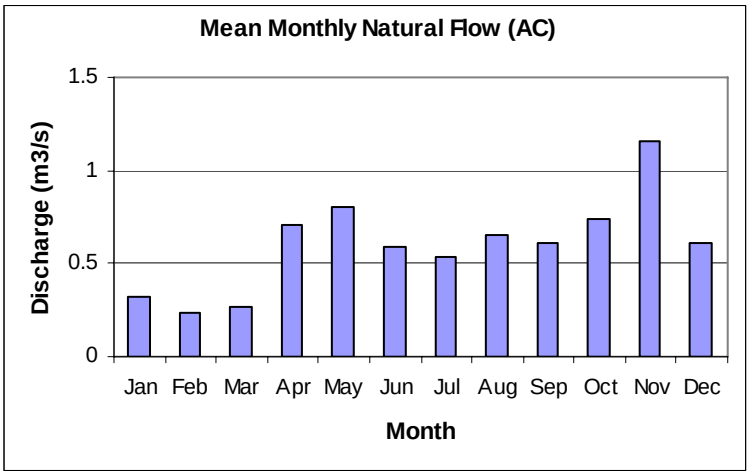
Figure 4: Mean, maximum and minimum annual rainfall for stations in the catchment

There is one evaporation recording station in the Sirimon Catchment (Kalalu station). Data from this and surrounding stations indicate that mean annual evaporation in the catchment as measured by a U.S. Class A pan evaporimeter is between 1700 to 1900 millimeters.

1.2.2 Hydrology

River gauge height and discharge records exist for one stream gauging station (AC) with data existing for the period 1960 to date. The Location of this and other river gauging station are shown in figures 10.

Figure 5 shows a plot of the monthly average naturalized discharge at the AC River Gauging Station.



Analysis of the naturalized streamflow data shows a high variability and seasonal fluctuations. While the mean flow for the period Jan 1985 to Jun 2002 is 1.122 m3/sec, the minimum and maximum recorded for the same period are 0.056 and 31.191 m3/sec respectively.

Figure 5: Monthly average naturalized discharge at AC

The naturalized stream flow at AC has high variability indicating a strong flashy characteristic (Figure 6). From observation, the behavior of this river looks quite different from that which is expected under natural conditions. This results from the heavy utilization of the river flows through abstractions to support human, livestock and agricultural demand. Though a perennial river, the Sirimon at times dries up in the lower parts during the dry months of February to March.

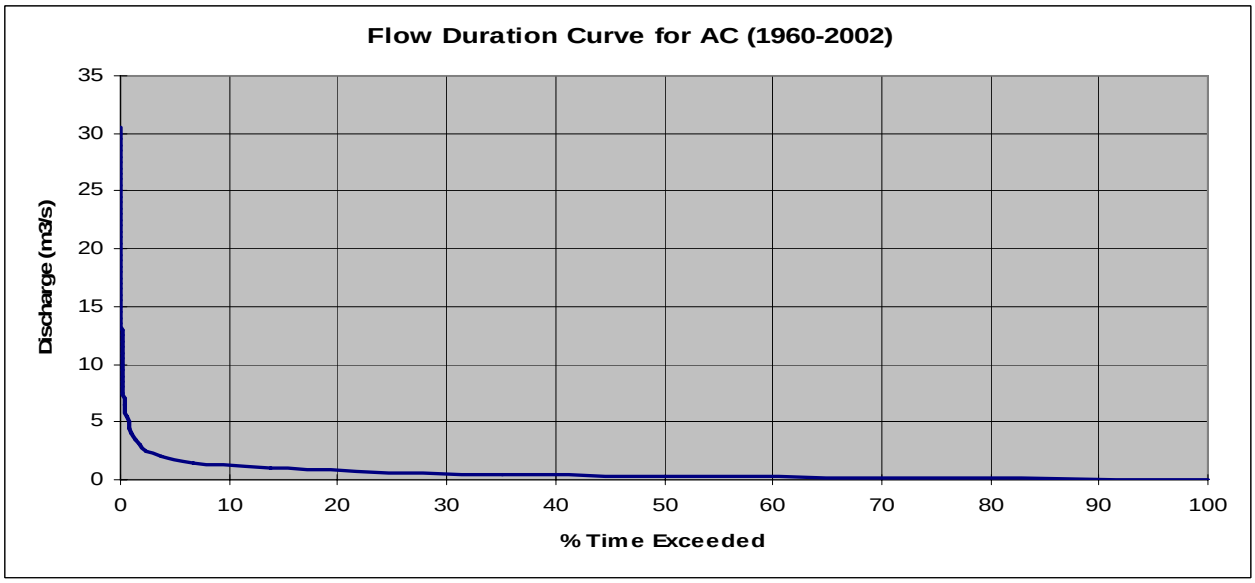


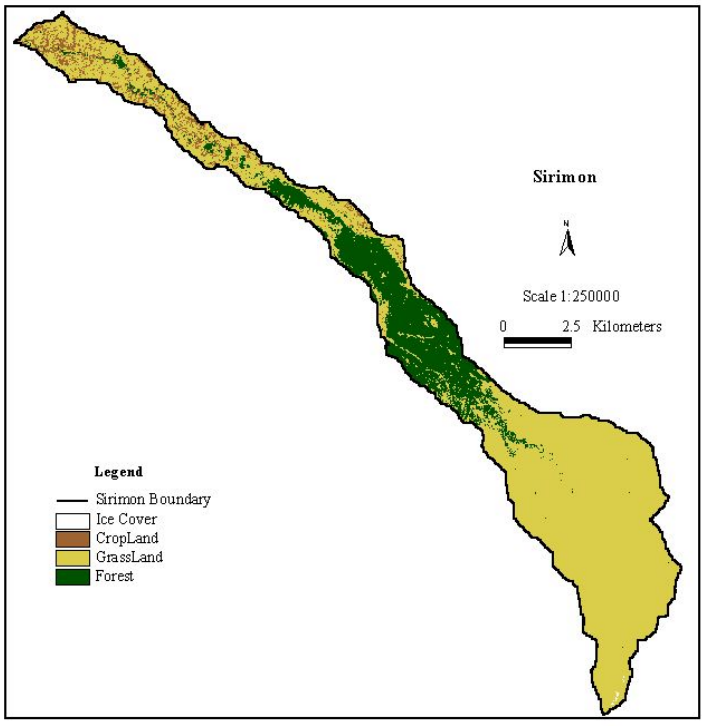
Figure 6: Flow Duration Curve for Sirimon River At AC

The Sirimon river does exhibit mild flooding characteristics. The ten highest recorded flows at the outlet of the catchment fall within a range of 14 and 30 m3/sec. The main effects of the observed mild flooding include improvement of grazing pasture and the destruction of the road communication network in the catchment which comprises of dry weather roads in an area predominantly having black cotton clay soils.

The allocation and control of use of this water within the catchment is a major issue with major environmental and social implications. Conflicts of interest exist between landholders wishing to utilize water resources to diversify their land use and grazers who rely on beneficial flooding to feed their stock. There is also substantial concern that increased levels of water resource development will have severe impacts on the natural environment.

1.3 Settlement and Land Use

Following Kenya's independence in 1963 there has been a continuous effort by both the government and private companies to resettle the landless Africans. Settlement schemes were started and subdivision of white owned farms was started soon after. The Sirimon catchment is among the early settlements on the Ewaso Ngiro basin. While it was a livestock and wheat production area in the 60's it now comprises small scale settlements and large scale farming concerns as well. Current settlers practice a combination of rain-fed and irrigated farming. Figure 7 shows the various current lands use types in the catchments and Table 1 indicates that 15.7 % of the catchment falls under reserved areas; forests and ice cover zones.



(Source: Adapted from Niederer 2000)

Figure 7 Land Use Types in the Sirimon Catchment ni 1995

Table 1: Land Use Types in the Sirimon Catchment

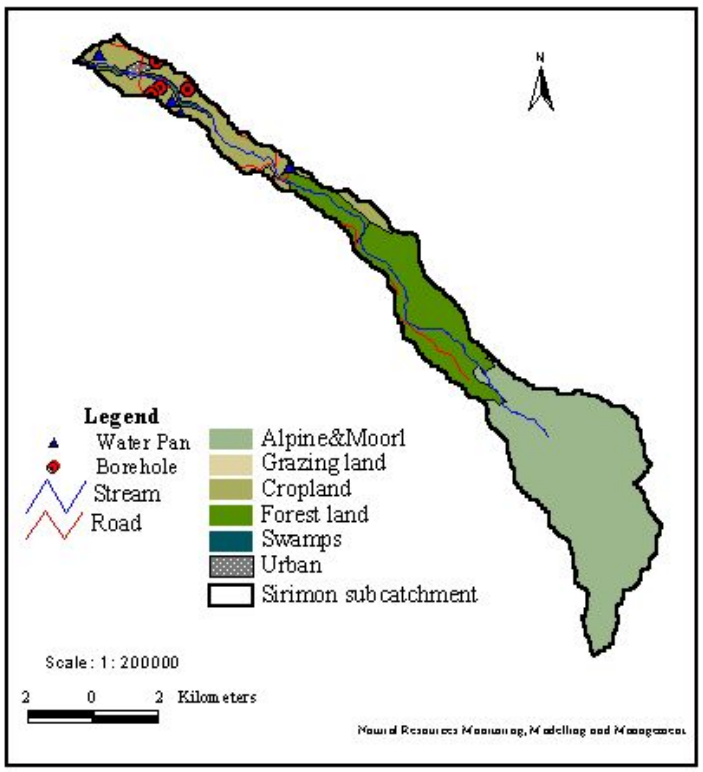
Land Use Type	Area	Proportion of Catchment Area (%
Cropland	7.00	9.15
Forest	15.65	20.44
Grassland	53.84	70.34
Ice Cover	0.05	0.06
Water Body	0.01	0.01

(Source: Adapted from Niederer 2000)

The last few years have seen an increase in cultivated and irrigated land in comparison to that in 1998 resulting to major challenges on water management (NRM3 Database, 2003).

1.4 Other Water Sources

Considering the high water deficit situation especially in the lower parts of the catchment, additional water sources are required. This situation demands that other alternative water sources be utilized. Rainfall and flood flow harvesting as well as exploitation of groundwater are the main alternative sources being targeted. The existing pans and boreholes are shown in Figure 8.



There are four boreholes in use in the sub-catchment located on the lower parts around Umande town, just before river Sirimon joins to river Kongoni. One of the boreholes is dry while the other three are not working.

There are currently three pans in use in the sub-catchment. One of the pans, Mworoga pan, owned by Mworoga water project, was initially meant to store water for use during the dry season and later broadened to include fish farming project. The fish project, however, is largely neglected due to management problems. The other two pans are predominantly used for livestock. There are also some pans within a distance of 1km from the Sirimon subcatchment boundary.

Figure 8: Distribution of Pans and Boreholes in Sirimon catchment

1.5 Economic Activities and Development

Among the main economic activities of the catchment include rainfed/ irrigated crop production, livestock production, mountain climbing/tourism and fish breeding all mainly for subsistence. Rainfed crop production is practiced by small-scale farmers typically owning plots of five acres or less. Production under this system ranges from average to poor and includes such crops as maize, beans, cabbages and potatoes. Irrigated agriculture takes a more commercial perspective with a well-established horticulture system. Homegrown is a major horticultural establishment in the area. The company pumps water from the Sirimon River, which is used directly in the irrigation system, and also pumps into their dam (Capacity 50000m^3) at Sirimon Farm for use during the dry season. Their irrigation needs are also partly met by water from the Sirimon Water Project and flood storage on another dam built along the Kongoni River.

The company encourages smallholder irrigation through an out-growers scheme extending outside of the sub-catchment. This comprise of small irrigated plots ranging in size between 0.5 to 3 acres and sourcing irrigation water from communal water supply systems or individual river water abstractions systems. All the large-scale water projects support some irrigated agriculture. The success of this smallholder irrigation system is partly attributed to the existing marketing systems within the area. To a small extent, produce brokers existing in the area purchase and deliver produce mostly to Nairobi. Other marketing companies which play a relatively small role are Everest and Kenya Horticultural Exporters. The main horticultural crop is snow peas but tomatoes, cabbages and onions are also produced.

Livestock rearing is a dominant primary industry in the catchment. Beef cattle and sheep for wool production are the most common forms of grazing. It is projected that the catchment currently supports 4863 shoats and 5561 large stock.

Agricultural production in the Sirimon Catchment is diverse, incorporating food production, horticulture and growth of pasture and fodder crops. Irrigated crop production is a major economic activity and covers an area of 350 acres. This sector has developed over time with the most rapid changes having taken place between 1992 to the present.

Discussions with the communities within the catchments yield the following as the main resource of management problems:

1. Low river flows
2. Poor road accessibility during wet period
3. Hunger and poverty
4. Decline in tree products
5. Water Pollution (sediments and chemicals)
6. Low soil fertility
7. Water borne diseases
8. Formation of hard pans
9. Poorly developed tourism income
10. Low rainfall and availability
11. Inadequate supplemental water sources
12. Nutritional diseases in livestock
13. Inadequate pastures
14. Low livestock and crop production
15. Decreased indigenous tree species

2 Water Management in the Catchment-Water User Associations (RWUA)

2.1 Background of the Water Management Situation

Management of water resources in the Kenya is vested in the Department of Water Resources (DWR), in the Ministry of Water Resources (MWR) as per the Water Act (Cap 372 of the Laws of Kenya).
This involves, among other activities, monitoring and assessment of the water resources availability and potential, developing water resources, apportioning/allocating the resource to those who apply for its use through issue of water abstraction permits and implementing allocations and other rules established to foresee the utilization of water resources.

Management of water resources in the region has been hampered by many problems. Among the most notable are:

1. Lack of readily available information and data on water resources management such as water availability and use.
2. Lack of adequate resources for the implementation of the Water Act. During the last decade the financial budget available to DWR to manage the river water resources has declined. This has led to low or lack of funding for such important activities such as mobilizing hydrologists and water bailiffs to undertake field monitoring exercises.
3. Increased water demand against an almost static supply. Domestic, livestock and irrigation demands for river water resources have increased substantially. Additionally, access to the rivers has increased dramatically due to settlement/subdivision of riparian land, meaning that the number of commercial and domestic abstractors has grown dramatically. Furthermore, awareness has increased in regard to the commercial value of water, specifically for irrigated horticultural and floricultural activities.
4. The absence of tight government control has effectively provided an open access condition in which water abstractors have abstracted on a “take as much as possible” basis.

5. Lack of strong participation by the local communities and water resource users in water resources management. For a long time, water resources management has been taken as a concern of the DWR.
6. Lack of effective adoption of high water efficiency and water harvesting techniques in production systems.

Arising from this situation, the Sirimon River is now increasingly experiencing prolonged low flow and dry periods. The river is heavily utilized for irrigation purposes by both large scale horticulturalists and small scale irrigators. This situation results in conflicts between the various users as well as between the upstream and downstream water users. Furthermore, the downstream communities are forced to seek alternative water sources, which may be of poorer quality, thereby increasing health risks as well as the labour and cost required to fetch the water

2.2 Role of the River Water Users Associations

It has been recognized that a water resource or supply is more likely to be managed sustainably if the users and stakeholders are involved in the management of that resource. Currently this involvement is being realized through the working of River Water User Associations (RWUA). A River Water Users Association is an association representing all the water abstractors of a particular river and other identified stakeholders. The primary role of the RWUA is the representation of the interests of the river water users and to package and channel community participation in such a way as to compliment the Department of Water Resources in the management of water resources.

The main areas of participation by RWUA is seen as:

- Raising awareness in regard to water permit restrictions, water use efficiency and water demand by various users and uses;
- Monitoring local adherence to permit limits and conditions;
- Providing a forum to disseminate government policy and decisions in regard to water abstraction;
- Providing local manpower and transport to assist in water resource monitoring;
- Contribute to the process of developing water development plans;
- Raise awareness and contribute in the catchment conservation efforts; and
- Work out methods of preventing conflicts, and where they occur, be active in resolving them thereby contributing to establishment of harmony.
- promote efficient, proper and sustainable water use
- promote soil and water conservation practises within the catchment area; (d)
- promote the conservation of the water quality; and
- promote a situation in which the available river flow is reasonably shared in a manner that recognises the priority ranking of water use
- provide a forum to discuss, prevent and resolve water use conflicts
- promote dialogue between the water users and the government in regard to water policy and enforcement of the Water Act; and
- promote a situation in which all modifications to existing river abstractions and all new river abstractions must be considered by the Association before being approved by the relevant government water boards.

2.3 Current Status of the River Water Users Associations in the Basin

The RWUA's are registered under the Societies Act which confers them a legal status. This implies that they can sue or be sued, enter into contracts, and own assets. However in terms of an explicitly specified mandate, the current water resources management laws do not confer any particular role on RWUA in the water management process. The Water Bill 2002 which has been passed by parliament has encouraged the role of the RWUAs in conflict resolution and co-operative water management without defining a specific mandate.

So, as much as the RWUAs want to be involved in the water management process which has been strongly recommended in recent times, there is no statutory role for the RWUAs. This has created a situation where they have to negotiate for a role with the relevant mandated organs a process that is strongly influenced by the existence of goodwill. This negotiation has been noted to present itself in two forms. One, where the RWUA presents as a watchdog to monitor and challenge DWR on its performance and its decisions or two, where the RWUA presents as a partner in the water management process taking over some of the functions of the DWR such as local water use control, regulation and monitoring. This is a role that has to be negotiated and implemented avoiding creating competition between the RWUA and the DWR. This has become achievable by recognition of the fact that in reality, neither party can undertake effective river water management without the other party exercising its responsibility and performing its duties. For example, if both parties jointly agree on a water rationing schedule in a time of drought, then the RWUA can monitor and enforce it at the local level, and if need be, the DWR can be called in to take legal and official action against offenders. For DWR to monitor and enforce at the local level would require resources which are not available.

Effective collaboration between the RWUA and the DWR can only be achieved by effecting some structural changes in the current water management system. Among the important aspects to be considered in such changes are:

- RWUA's should be allowed to consider water abstraction applications prior to government approval. This would provide a mechanism of notifying the public about impending applications, which is essentially consistent with the spirit of the existing water law. This would have the advantage that a developer can invest and proceed with confidence if the other stakeholders have approved the new abstraction. Once a developer has invested, the stakes are higher and water use conflicts are more difficult to prevent and resolve.

- RWUA should be entitled to representation on District and Catchment Water Boards or the CAAC. It is not fair to expect the RWUA to enforce abstraction levels along the river, if it has not been party to the allocation decisions. The RWUA represent the stakeholders on each river and therefore their membership on the Boards would provide a mechanism for stakeholder participation in the official process of managing river water resources.

- The existing situation in which water permits are described in terms of flood flow and normal flow is very difficult for water users and water bailiffs to follow and enforce. A water user does not know whether the river, at any specific moment, is in a state of "flood flow" and he/she can abstract for irrigation purposes, or a state of "normal flow", in which case he/she cannot abstract for irrigation purposes. An alternative practical distinction between flood and normal periods should be established. This can be based on statistical representation of the long term hydrological data in which "flood flow" is expected to exist during certain months or between certain calendar dates. These periods can be defined and can therefore be understood, followed and enforced by the parties concerned. Alternatively, staff gauges can be installed along a river profile with marks indicating threshold values for abstraction conditions.

2.4 Aims and Objectives of RWUAs within the Ewaso Ngiro North Basin

The following are some of the achievements of the RWUAs:

- Established fora to discuss water use issues and to resolve water conflicts;
- Raised awareness of community ownership and responsibility for the river resource;
- Raised awareness of proper water use;
- Development of a common sense of community among all the abstractors;
- Familiarisation and respect among different communities and different ethnic groups;
- Resolution and enforcement of water rationing schedules during periods of drought;
- Co-operation with government offices in regard to water permits, and other river related activities;
- Resolution and prevention of water use conflicts
- Ban and enforcement of water polluting activities (washing clothes and water livestock in river)
- Participation in river abstraction surveys and the preparation of catchment water development plans.

One of the main tasks facing the RWUA is that of popularising the use of measuring and controlling devices as well as abstraction quantities controlling procedures on river water abstractions.

These could include devices installed as part of the abstraction works and serve the purpose of controlling and regulating the amounts of water taken of the river or agreed on operation practices that serve to regulate the water taken off from the river by users of portable pumping equipment. Examples include:

(a) Gate valves along pipelines. These are most effective when installed in such a way that they are lockable after adjustment and setting.
(b) Sluice gates along canal abstractions. These are most effective when installed in such a way that they are lockable after adjustment and setting.
(c) Flow dividers. These are designs that hydraulically divide flows in predetermined proportions and are especially useful for handling low flows.
(d) Pumping schedules and timetables or limitation of total acreage under irrigation at any one time.

2.5 The Sirimon Water Users Association

The concept of community based water resources management for the Sirimon river has been discussed for a number of years, with references being made about discussions that were held way back in 1997. These discussions have targeted addressing the problem of decreased river water availability especially with increased crop irrigation activities resulting from a rapidly involving horticultural industry. Stakeholders have therefore used available opportunities to lobby for the establishment of a formal RWUA. To date, this has not come to being and the Sirimon RWUA remains in a formative stage. Discussions with users of water resources from this river reveal that the main hindrance has been the lack of group formation skills in light of the diverging expectations of the various users a factor that has resulted in a longer group formation process. Despite the lack of a formally and legally constituted RWUA, the stakeholders during recent times have worked together towards improving river water resources management in the catchment. For instance, Homegrown Ltd, a major player in irrigation in the area support the Sirimon Water Project. This kind of collaboration and involvement has maintained a healthy debate on water use in the area covering such issues such as control of abstractions and efficiency of use. However these activities and efforts have not resulted in the development of a RWUA though this has bee raised as the way forward for

the community. Awareness has been created through the activities of other RWUA's and the current feeling among the users of this river is that the water scarcity situation for their river deserves improved and inclusive management efforts.

As stated above, the RWUA is not formally established for this catchment. Nevertheless, a consideration of the water management challenges in the catchment indicate that such an association would be instrumental in improving certain management components. Some of these key components are listed below:

i). Provide a forum to resolve conflicts between users resulting from water scarcity during the dry season
ii). Promote harmony between the upstream and downstream users through conflict resolution and carrying out of activities that reduce adverse effects of water abstractions for others.
iii). Lobby for processing of permit applications for users and promote legal water use activities that recognize the needs of all the communities relying on river water from the Sirimon River.
iv). Promote good water management practices to make efficient and sustainable use of the river water
v). Promote water conservation practices to ensure sufficient river flows to meet the demands of the environment, the wildlife, the livestock and all the communities who rely on the river water
vi). Lobby the government to provide incentives such as tax exemptions for development of flood storage facilities in the horticultural industry.

Like other functional RWUA in the basin, it is considered that the stated improvements will be met by providing an environment that facilitates and allows for:

i). Exchange information and ideas on river water use.
ii). Discuss potential projects or developments that may affect water usage with a view to obtaining the consent of other Association members.
iii). Resolve conflicts on water use.
iv). Monitor water availability and use

The membership of the RWUA is also expected to be in conformity with the current functional RWUA's where it is open to the following:

i). Riparian land owners, or their representatives, of the Sirimon River
ii). Representatives of water projects that draw water from the Sirimon River
iii). People abstracting water directly from the Sirimon River
iv). Technical advisers and/or government officials who are requested by the Association to serve in the interests of the Association as "observer-members"
v). Stakeholders who utilize water though indirectly such as the tourism industry and environmental groups.

3 Methodology of Water Resources Assessment

River discharges for this river are monitored among the various others originating from Mount Kenya. The River Gauging Station for the Sirimon River is equipped with R16 OTT type autographic water level recorder located at UTM Grid References (AC- 281477, 9987966)

Information of measured river flows is available as daily discharge data at points of measurement as well as in various summary formats such as the mean monthly flows and flow duration curve.

Of importance are the details of the river water abstractions points to complement the above data in understanding the quantitative aspects of river water. This assessment has been an ongoing concern within the abstractions monitoring initiative of NRM3. To complement this a short campaign held between 24th September, 2002 and 28th September 2002 by two documenting teams has been carried out targeting the following information:

i) Geo-reference and ownership
ii) Principal water uses
iii) Water resources apportionment, authorizations and permits
iv) Description of abstraction works, peak capacities, measuring and controlling devices
v) Abstraction quantities estimates and measurements
vi) Water quality

The inventory was carried out starting from the upper reaches of the Sirimon river system and moving downwards up the confluence of Sirimon and Kongoni. The teams carried out an inventory of the river water abstraction systems which included the following tasks:

i) Walking along the river and identifying points of the river water abstraction.
ii) Following a provided check list, making notes of physical aspects of the diversion works, and making appropriate measurements.
iii) Making river or furrow gauging's to provide insight into amounts of abstractions by the larger abstraction systems and also the available flows at selected reference points.
iv) Looking for and identifying a suitable respondent to provide additional information as outlined in the check list.
v) Taking photographs of the abstraction works or relevant aspects of the abstraction system.

To access the quantities of river abstractions, the following methods were used

(a) Pumping Capacity and Pumping Schedule

This involved the collection of information on the pump used for the system and using this information to determine the operating pumping capacity for the system. Additionally, the operating time table was collected to determine the monthly hours of operation and the two used to compute an average rate of abstraction.

(b) Upstream and Downstream Double Gauging

River flow measurements were made by use of current meter gauging upstream and downstream of the abstraction point. The difference of the upper higher value minus the lower value defines the abstraction amount.

(c) Demand Based Estimate

Where abstractions quantity measurement was not possible especially for the small abstraction points where a double gauging for instance does not yield dependable results, or where pumping information is not available, then an estimated based on the demand was used. The considered demand components were; Irrigation, domestic and livestock water demands. The following demand computation formulae were used:

Water Demand (Dw) in m^3/day is given by the following expressions

People: Dw = No of People X 40 Liters per Day X 10^{-3}

Livestock: Dw = No of Livestock X 60 Liters per Day X 10^{-3}

(Adapted from MoWD, 1986)

Irrigation: The following parameters were assumed in calculating irrigation demand.

Reference Potential Evapotranspiration **ETo = 5mm**

Crop Factor **Kc = 0.8**

Irrigation Efficiency η **= 70%**

$Dw = ETo \times A \times 4047 \times 10^{-3} \times 0.8 \times (100/70)$

Where

A = Area in Acres

(d) Volumetric

(e) Measurements and Pumping Schedule

(Adapted from FAO, 1977)

This involved the determination of the pump capacity by making volume –time measurements. Additionally, the operating time table was collected to determine the monthly hours of operation and the two used to compute an average rate of abstraction.

The Equivalent Continuous pumping rate for this assessment method is calculated using the expression:

$Pr = Pc \times (Nm/30) \times (Nh/24) \times 86.4$

Where:

Nm = Number of pumping days per month

Nh = Number of pumping hours per day

Pc = Pumping Capacity in l/s (measured or picked from pump ratings)

Pr = Equivalent Continuous pumping rate (m^3/day)

(e) Channel Current Meter Gauging

This involved the use of a velocity area summation method with the flow velocities at various vertical sections of the flow path being measured using Current Meter equipment.

4 RESULTS AND DISCUSSION

The water scarcity situation in the Sirimon catchment is seen to be moderately severe with water conflict situations arising during the period of January to March. For instance, Sirimon, Ngenia and Umande farmers demonstrated in Nanyuki town against over abstraction from Sirimon river citing Home grown as the main culprit in April 2000. Home grown maintained that was that it was using water from their dams but farmers insisted they were abstracting from the rivers. The farmers where joined by the area member of parliament (MP). The figure shows large-scale irrigation farms as well as small-scale irrigation sites within and neighboring Sirimon catchment.

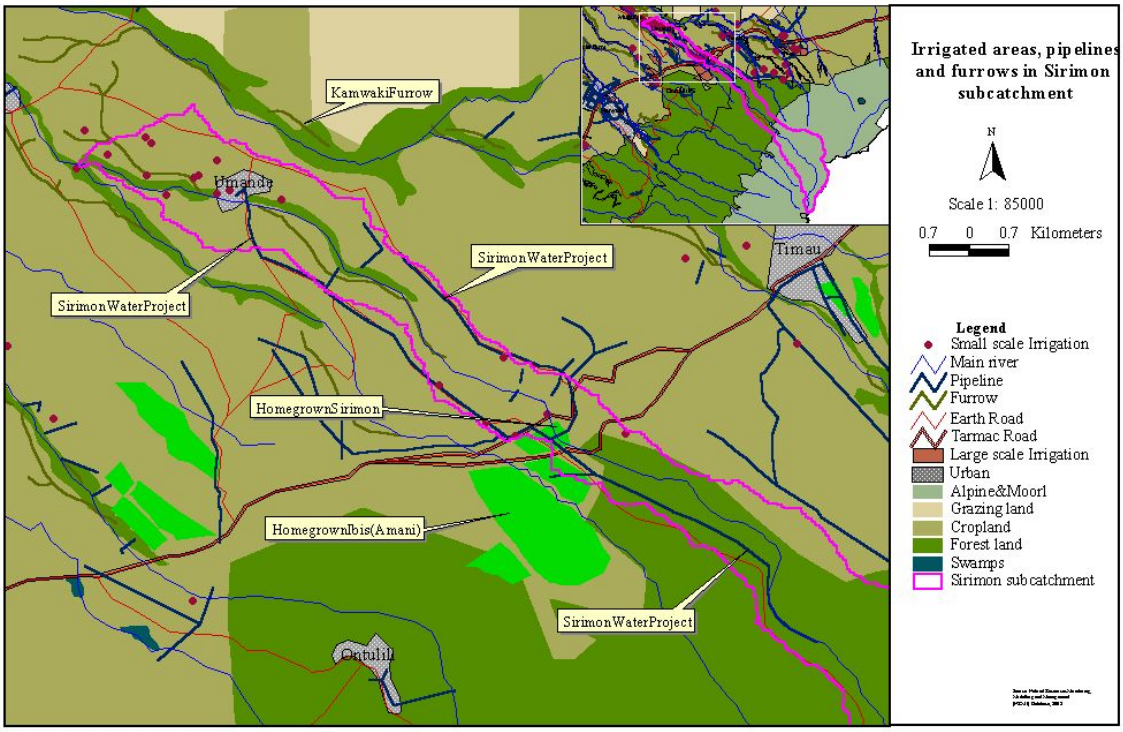
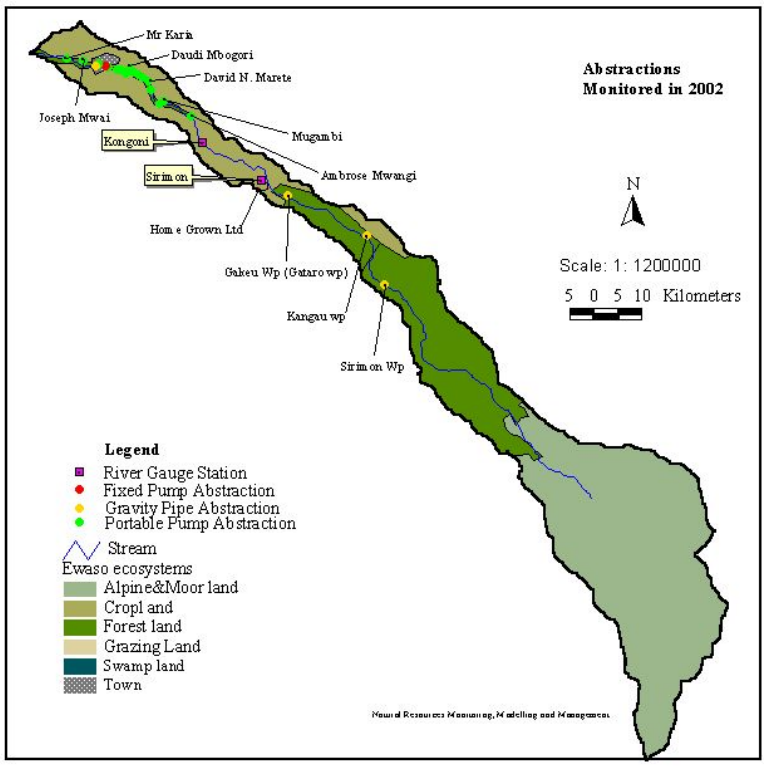


Figure 9: Irrigations areas and water distribution infrastructure within Sirimon Catchment

Involvement of the local community in water resource management is crucial to the success in improving this situation. As has been stated this river does not have a working RWUA. Nevertheless, current efforts are striving towards realization of such a management organ. We have considered some of the important recommendations in support of this process which are presented below.

The layout of the abstraction works along the Sirimon river is shown in Figure 10. It can be seen that the density of the abstraction points is quite high especially in lower sections of the river.

Figure 10: Layout of current abstraction works for the Sirimon river (September 2002)



A list of the abstraction points for the Sirimon River in presented in the table below:

Table 2: Summary of Abstraction Points along the Sirimon River

Index	Owner	Type of Abst	Measurement Method	Abst(m3/day)	UTM X	UTM Y
1	Sirimon Wp	Gravity Pipe	CM	4,593.89	303907	10003157
2	Kangau wp	Gravity Pipe	CM	186.62	303260	10004864
3	Gakeu Wp (Gataro wp)	Gravity Pipe	Dem	27.13	300530	10006247
4	Home Grown Ltd	Fixed Pump	CM	2,179.87	299456	10006400
5	Ambrose Mwangi	Portable Pump	Dem	11.56	297130	10009036
6	Mugambi	Portable Pump	Dem	17.38	296163	10009531
7	Mr Karobia	Portable Pump	Dem	11.56	296052	10009458
8	MCK Kianjogu WP	Gravity Pipe	CM	273.02	293710	10001621
9	Kinyua Wa Nguku	Portable Pump	Dem	11.56	295740	10009925
10	David N. Marete	Portable Pump	Dem	17.34	295678	10010234
11	Josphat Gachagua	Portable Pump	Dem	11.56	295426	10010396
12	Joseph Gikaria	Portable Pump	Dem	5.78	295316	10010460
13	Ndegwa Kiai	Portable Pump	Dem	23.13	295318	10010471
14	Roise Wanjeri Waruka	Portable Pump	Dem	11.56	295111	10010540
15	Daudi Mbogori	Portable Pump	Dem	23.13	295002	10010677
16	Muriuki Karia	Portable Pump	Dem	69.50	294863	10010528

17	Eliza	Portable Pump	Dem	2.89	294909	10010585
18	Zacharia Waweru	Portable Pump	Dem	23.13	294674	10010625
19	Maina Wamai	Portable Pump	Dem	23.13	294565	10010656
20	Monica Nyaruai	Portable Pump	Dem	46.25	294253	10010729
21	Mohammed Amin	Fixed Pump	C/S	47.52	294159	10010770
22	James Warui	Portable Pump	Dem	2.89	293912	10010860
23	Munyi	Fixed Pump	Dem	462.51	293889	10010837
24	Rosalid Wangui Makunu	Portable Pump	Dem	46.25	293889	10010837
25	Godfrey Kariuki	Portable Pump	Dem	5.78	293866	10010828
26	Joseph Mwai	Portable Pump	Dem	11.56	293364	10010936
27	Mr Karia	Portable Pump	Dem	46.25	292794	10011050
28	Jerad Ngaca	Portable Pump	Dem	17.34	291308	10011341
29	John Wachira	Portable Pump	Dem	23.13	291311	10011358
30	Johnson Mureithi	Portable Pump	Dem	2.89	291076	10011505
31	Munyi Aderson	Fixed Pump	Dem	231.26	290903	10011484
32	Mworoga W.P.	Gravity P	CM	3931.00	293820	10010759
33	Gitonga Ndegwa	Portable Pump	Dem	11.56	289719	10013142
34	Watene Mbugua	Portable Pump	Dem	17.34	289607	10013123
35	Michael Muriithi	Portable Pump	Dem	17.34	289608	10013149
36	John Watene	Portable Pump	Dem	23.13	289511	10013132
37	John Watene	Portable Pump	Dem	34.69	289511	10013313
38	John Njenga	Portable Pump	Dem	11.56	289284	10013317
39	Silas Njoroma	Portable Pump	Dem	23.13	289231	10013387
40	Francis Muriuki	Portable Pump	Dem	5.78	288865	10013480

Source (NRM3 Database, 2003)

*: The following Combination of abstraction quantity and estimation methods has been used

1. C/S Pumping Capacity and Pumping Schedule
2. DG Upstream and Downstream Double Gauging
3. Dem Demand Based Estimate
4. V/S Volumetric Measurements and Pumping Schedule
5. CM Channel Current Meter Gauging

As shown in the above, there are 40 documented abstraction points along the Sirimon River in comparison to 25 in 1997.

On the basis of above information, a number of observations have been made and will be presented in the sections that follow to enhance the understanding of the river system.

4.1 Legal Status of Water User

Analysis of permit records (NRM3 Database 2003) indicate 32 existing permits for the Sirimon river. Of these 9 permits have been authenticated to be in use in the sub-catchment (Table3). The remaining 23 permits do not have a matching user from the inventory and are presented in Table 4.

Normal flow water permits range between 232m^3 and 1m^3 per day while flood flow water permits range between 2000m^3 and 10m^3 per day. Total Normal flow allocation of the 32 permits is 880 m^3 per day while the total flood flow allocation is 11217 m^3 per day. Water permits for flood and normal flows are concentrated in the lower region where irrigated farming is carried out.

Table 3: Permits in use in Sirimon River Catchment

Permit Name	Current User	Permit Number	LAPSE	ISSUED	NF	FF
Gakeu Water Asso.	Gakeu Wp (Gataro wp)	1182	10/03/1993	10/03/1992	77.7	3000
Daudi Mbogori	Daudi Mbogori	1867	31/10/1990	26/10/1965	3.17866	22.49554
Mohhamed Amin	Mohammed Amin	2098	30/11/1987	27/08/1969	3.16643	3.16643
M. Kuria, J. Ngundo & K. Mugo	Mr Karia	16262			0.91	54.55
Sirimon Self Help Water Project	Sirimon Wp	21743			45.4	908.75
Adason M. Nyoko	Munyi Aderson	26578			5.825	200
Homegrown Sirimon	Home Grown Ltd	27763	09/05/2004		0.864	84.8
Umande Water Association	Mworoga Water Project	232112			232.12	1080
Umande Water Association	Mworoga Water Project	13593			22.7	1090.02

Table 4: Permits not in use in Sirimon River Catchment

Owner	PMTNO	LAPSE	ISSUED	NF	FF
Albert G. Kirigu	25138			0.78	30
Bongo Farm	27810			5.825	200
Charles K. Marete	28045			0.9	0
Daniel M. Mburugu	27435			1.2	10
David Ndungu Ndirungu	25564			4.818	60
Denis Charles And V. Kandall	8387	01/09/77	21/03/64	21.27254	393.9088
George A. Webb	16213			15.91	454.55
George Webb	9305	02/02/92	22/03/72	54.2817	189.9858
Georgealexander Webb	9306	31/05/91	02/06/66	22.61736	1990.328
Isaac W. Mwangi	26272			2.58	30
James William Arnold Hearle	6050			21.598	0
James William Arnold Hearle	4411			0	0
James William Arnord	6058	31/10/88	01/11/63	21.51706	351.8528
Jane Nyokabi Eliud	26467			1.2	20
John M. Nganga	26288			2.59	40
Laikipia County Concil	13113	05/08/95	19/01/72	54.2817	0
Nderitu Gikaria & Partners	17812			16.4	454.6
Ngenia Estate	19141			184.9	0

Owner	PMTNO	LAPSE	ISSUED	NF	FF
Ngungurusaw Mills	17483			7.2	227.3
Peter Makuno	15338	16/02/94	16/02/93	2.455	209
Peter Matheri Gakuiya	24635			5.5	30
S. M. Amin	9788	31/12/93	21/09/93	0	81.82
Umande Pry. School	17478	13/02/03	15/09/82	39.174	0

Source (NRM3 DATABASE, 2003)

The issue of legality of water use is important in gauging the level of compliance with the Water Act as well as the success of policing and controlling activities. Analysis of the legal status of the documented abstraction points is presented in Figure 11. This analysis is based on the status of water abstraction permits for the users and is based on the following classification categories and their interpretation:

Permitted: A permit exists for this abstraction point
None: No permit has been issued for these abstraction works.

Applied: No permit is available but the there exists an application for a permit with the Water Department

Not Known: The inventory has not determine the legal status of the abstraction works from the owners who are unavailable or from office records.

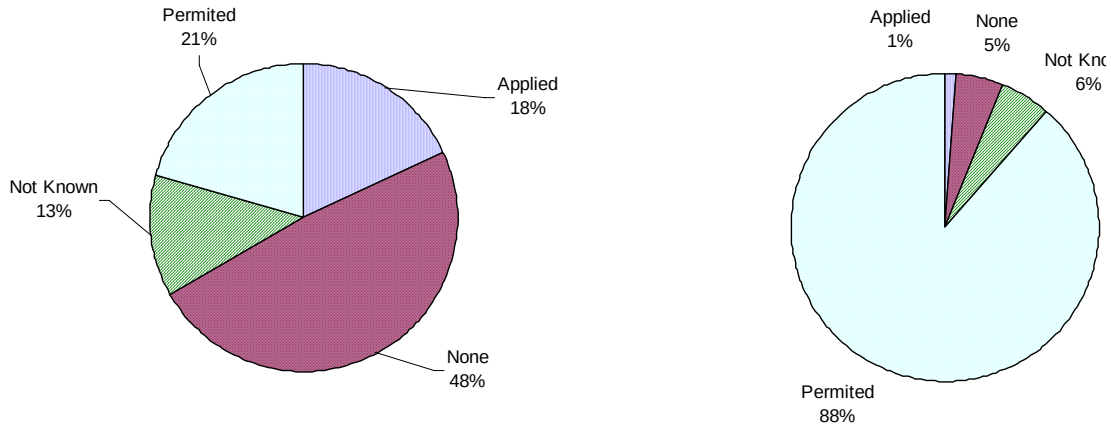


Figure 11: Analysis Of The Permit Status Of Abstraction Works By Number Of Points On The Left, And By Quantity Of Water Abstracted On The Right

For instance, 21% of the abstractions points are permitted and take up 88% of the water. Among these points operating with permits, discrepancies exist between the permitted amounts and the abstracted amounts. Overall, 880 m^3/day are authorized for use during normal flow periods, 11217 m^3/day during flood flow against the abstraction level of 12543 m^3/day during the monitoring period. Since flows at time of measurement fall within the normal flow levels, this means that the users utilize approximately fourteen times the quantities allowed. Total

abstraction quantity for the river was found to be 12543 m^3/day as compared to 5317 m^3/day by 1997 when another detailed monitoring had been done.

This information will help the RWUA's to develop an agenda for controlling abstraction amounts and pursuing legalization of the abstraction systems by monitoring the level at which the permit issuance process stagnates.

4.2 Abstractions Systems Analysis

A variety of abstraction systems are existing within the Sirimon River Catchment. Below is a list of their categorization with a brief description.

Fixed Pump	A permanently equipped pumping house at the abstraction point.
Bucket Scooping	The water is taken of by scooping with buckets and applying to irrigated plots using watering cans
Furrow	Open Canal (furrow) conveyance system.
Gravity Pipe	Flow through pipe conveyance from higher to lower elevation.
Portable Pump	Any pumping system that is taken to the abstraction point for purposes of pumping and then removed and kept elsewhere.

In the upper parts of the catchment, gravity pipeline systems dominate while the furrow systems are to be found in the lower parts where slopes permit open channel water conveyance without resulting in bank scouring and erosion. It should be noted that the majority of the abstraction works are by portable pumps. Though the abstractions amounts for these systems are significantly lower, they offer a big challenge in management and monitoring since they easily change their operations, relocate from time to time and require very little time for new establishments.

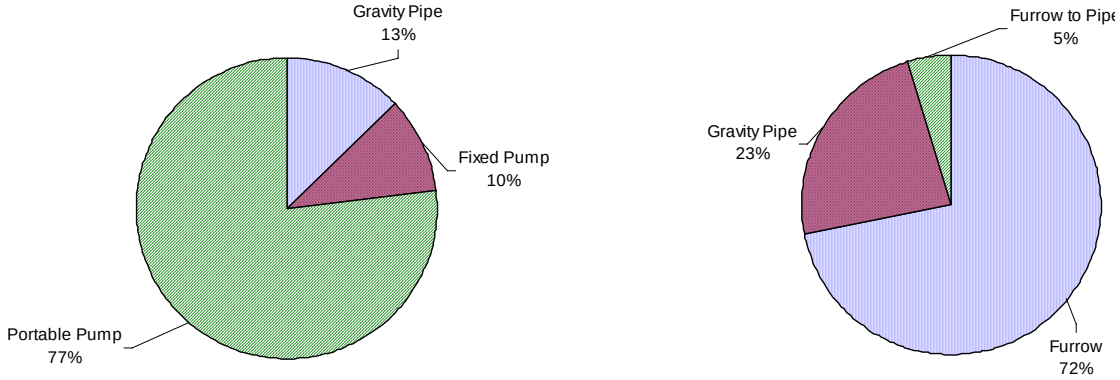


Figure 12: Analysis Of Abstraction Systems for the Abstraction Works By Number Of Points On The Left, And By Quantity Of Water Abstracted On The Right

It should be noted from above that though portable pumps account for 77% of the abstraction points, they constitute 5% of the abstraction volumes while the gravity pipeline systems accounting for 13 % of the points constitute 23% of the abstraction volumes. In this catchment, water abstracted through gravity pipeline systems dominates the total abstraction volumes. This information is useful in deciding infrastructure relevant in control and regulation of abstraction amounts. It is also useful in deciding how to allocate resources for monitoring as well as providing a basis of changing focus on the systems that are more crucial in terms of abstraction quantities.

4.3 Water Allocation Priorities Among Users

Perception of water users on the needs of other users especially downstream users is reflected in the way they allocate available water resources at point of abstractions. There are three distinct allocation options observed during the inventory. A consideration of both the design of the abstraction works and its operation was used in deciding the order of water allocation at the intake works. This gave the three categories to which the abstraction points have been subjected in the analysis presented in Figure 13

A The design of the abstraction works is such that the order of priority is a bypass pipe for downstream flow, then the abstraction conveyance and finally additional downstream flow through over flow.

B The design and operation of the abstraction works ensures that in the event of very low river flows, the abstraction requirement gets the first priority over the downstream release.

C The design and operation of the abstraction works ensures that in the event of very low river flows, the downstream release gets the first priority over the abstraction flow.

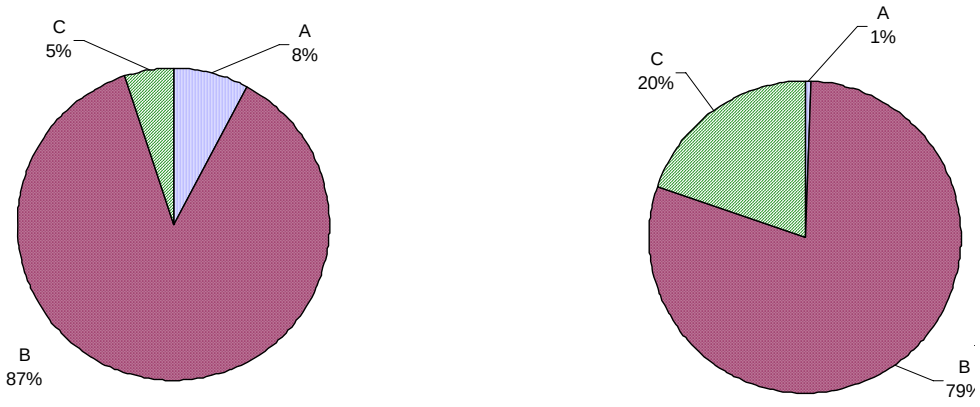


Figure 13: Analysis Of Allocation Priorities for the Abstraction Works By Number Of Points On The Left, And By Quantity Of Water Abstracted On The Right

It should be noted that the number of water abstractions with the downstream flow receiving less priority is quite high (87%)

4.4 River Bank Vegetation and Cultivation Activities

The type and density of river bank vegetation influence water. An assessment of these factors has been carried out by classifying the riparian vegetation as dense, medium or poor. The existence of agricultural activities (cultivation) right to the edge of the river bank was also noted. This information is presented in APPENDIX 1 for each of the abstraction points. A summary of the vegetation density is presented in Figure 14.

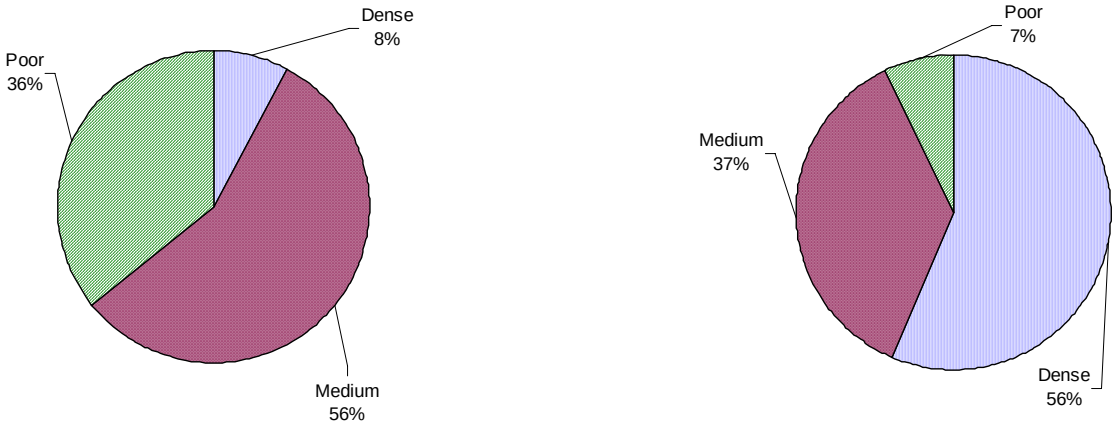


Figure 14: Analysis Of River Bank Vegetation By Number Of Points On The Left, And By Quantity Of Water Abstracted On The Right

36% of the abstraction points have poor riparian vegetation at the points of water extraction. These are points accounting for 7% of the total abstractions mostly being the small portable pumping systems. Because these systems require a lot of movement to and from the off take points, it signifies that they should be contributing substantially to the problem of erosion and hence water quality. This is compounded by the existence of cultivation right up to the river bank at many points (APPENDIX 1)

4.5 Distribution of Abstraction Volumes Among the Abstraction Points

Distribution of water abstraction volumes among the existing abstraction points varies significantly with the spatial layout of the abstractors which is also closely linked with the type of abstraction works. Higher up in the catchment, the abstraction works are made up of piped gravity systems which take up notable amounts of water. This distribution has a high significance in terms of management requirements. A fairly uniform distribution means that the abstraction points should receive fairly equal attention in their management such us controlling and monitoring. A skewed distribution suggests that more attention should be given to those that are contributing more to the total abstractions.

Figure 15 shows a plot of the proportion of abstractions against the abstraction points distance from the head abstraction point. This provides a visual illustration of the layout of the abstraction amounts indicating at what distance the water is taken off the river. In the present case, the distribution of abstraction amounts with distance looks quite irregular with the first abstraction point taking up a very high proportion of water (36%).

Figure 15: Proportion of abstractions against the abstraction points distance from the head abstraction point

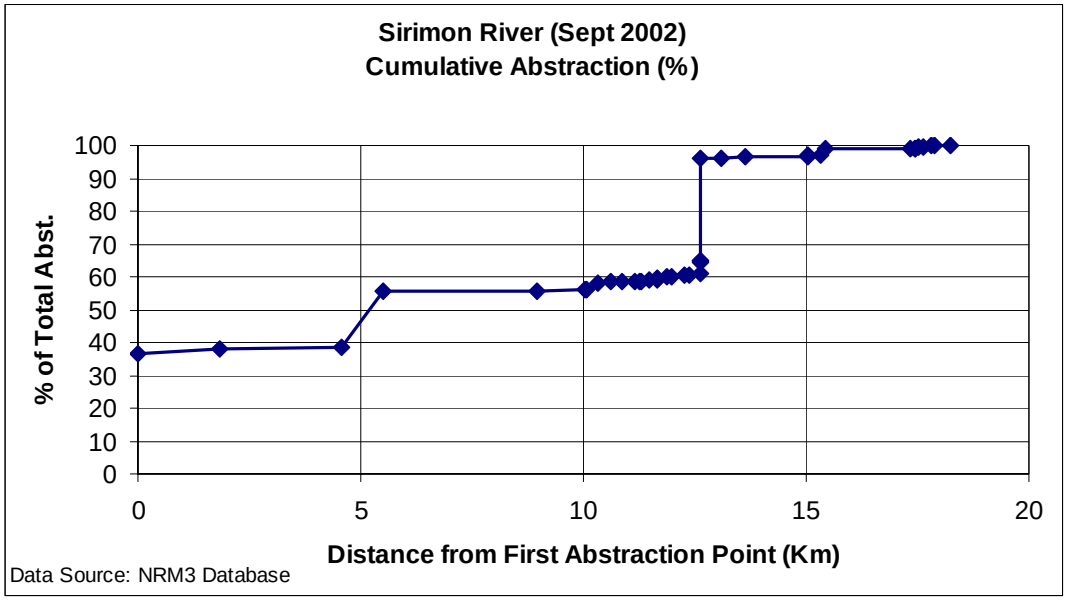
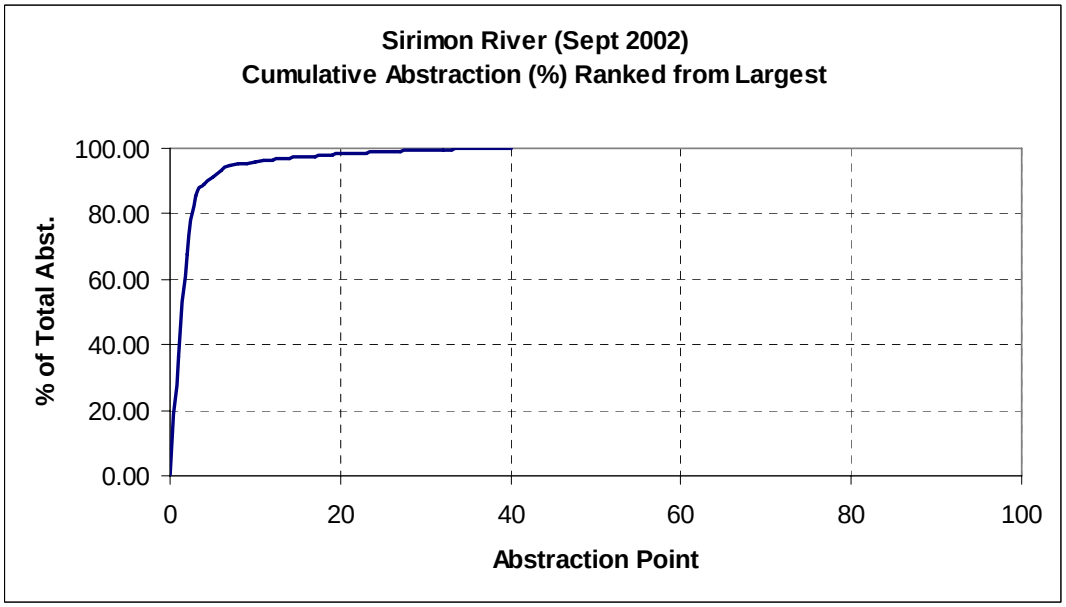


Figure 16 shows a plot of the proportion of abstractions against the abstraction points ranked from that having the highest abstraction quantity.

Figure 16: Plot of Proportion of abstraction quantity against the abstraction points



This has certain implications in terms of management. For instance it is observed that about 80% of the total abstraction volume is carried out by five abstractors. This can be used as an indicator

of the distribution of resources for monitoring especially where more rigorous monitoring is not possible for all the points.

Analysis of the Abstraction volumes has been carried out by subdividing the Sirimon River into two sections, from the source to the RGS AC and the rest of the section to the confluence with the Timau River.
As presented in Figure 17 it can be seen that for the first sections of the Sirimon Rivers, 24% of the available river flows is abstracted. 42% of available flow is taken up in the next section. Available flow in the analysis above has been derived from river flow gauging at the two points that was carried out alongside the abstractions inventory. Details of the riparian vegetation and the agricultural activity observed at abstraction point is presented in APPENDIX 1

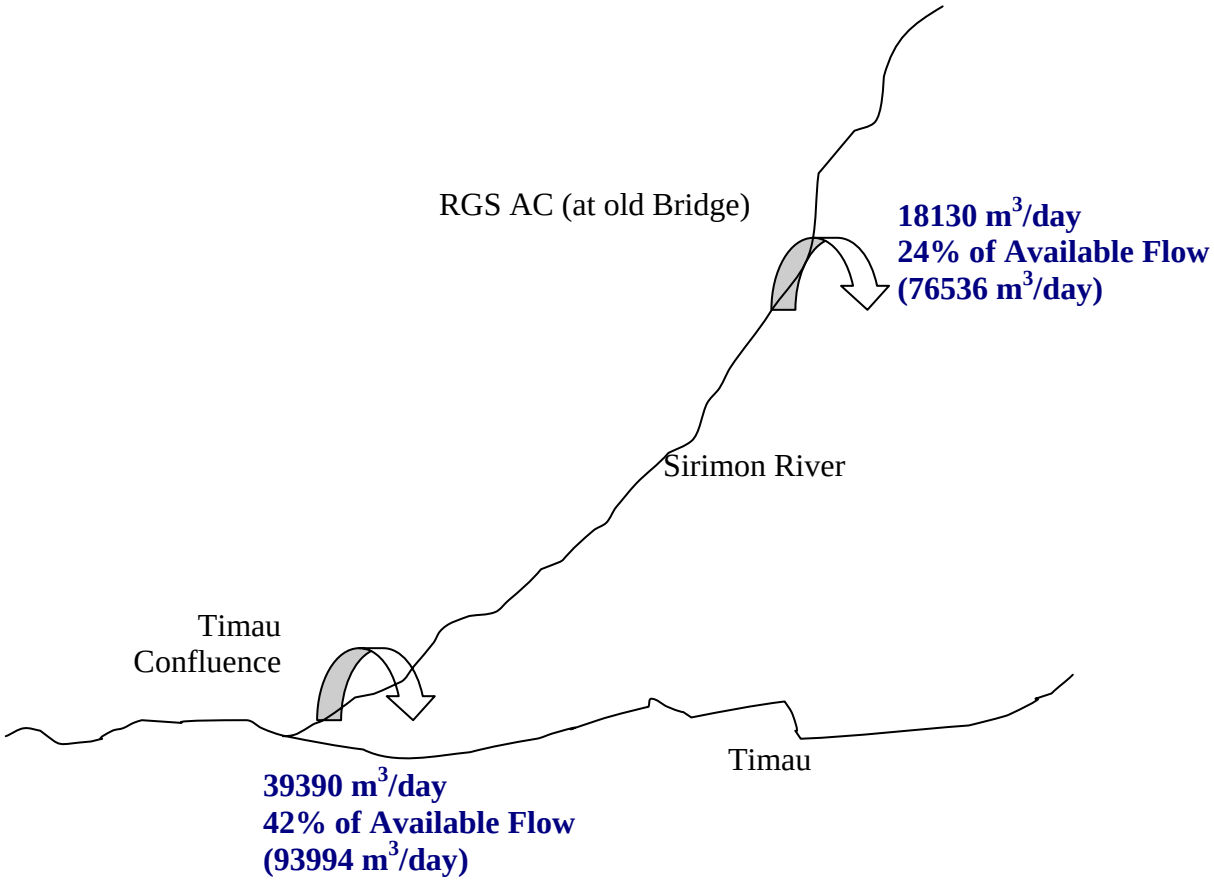


Figure 17: Schematic Diagram For The River Flow Quantities And Abstractions Quantities For The Sirimon River

5 RECOMMENDATIONS AND CONCLUDING REMARKS

This report has utilized a snapshot scenario to present water management issues for the Sirimon River. It has provided an insight into the developments over time in water resource use by comparing the current status with the last documentation in 1997. Because of the dynamic nature of water abstractions development, it is recommended that a monitoring update be carried out during different seasons to capture some temporal variations and trends. This task forms the core of any management strategy and it is best placed in the hands of the users through the RWUA. It is also important to note that this monitoring should be maintained and shared between the other rivers forming the Ewaso Ngiro river system as the interactions in utilization of the water resources are high. It is expected that the members of the RWUA's will provide feedback on any change within their systems in terms of changed abstraction works, changed legal status of abstractions and any required technical support to sustain a useful monitoring and reporting system.

As has been observed in this exercise, the majority of water users (82%) operate without valid abstraction permits. Even those who have permits operate in contravention of the permit conditions. Of critical importance is the lack of observation of the requirement to have measuring and controlling devices for the abstraction works as well as to have stipulated storage which for irrigation users is set at the equivalent to 90 days irrigation water requirement. This is attributed to the status of operation of the DWR. The permit issuance process is hindered by a number of factors the most notable being:

- Water abstraction patterns do not conform with current issued permits. The question raised by users is that where even those with permits experience water shortage as long as they are hydraulically disadvantaged. This lowers the value and meaning of the water abstraction permit in the eyes of the user.
- The Water Boards mandated to process and issue water abstraction permits meet rarely and infrequently sometimes as few as two times a year.
- There is only nominal representation of water users on the Boards and hence a lack of adequate of water users issues.
- No public notice of abstraction applications is given and hence the public has little knowledge of legal water users.
- There is no forum in which the decisions of the water boards are disseminated to the water users.
- Lack of financial resources to mobilize hydrologist and bailiffs to monitor resources and abstractions.
- Low morale within government officers to enforce water permit restrictions as this is considered "unpopular" and to deal with a situation which is considered overwhelming.

River water use in the catchment is therefore not firmly controlled. The cost associated with this resource is one where one pays for the diversion costs (diversion works maintenance, and pumping costs if any). Where such costs are low as in gravity pipeline systems which dominate abstracted volumes in the catchment, mechanisms to regulate usage amounts are poor. The resulting situation is one of an essentially open access situation for water resources use in which the "tragedy of the commons" results. The over abstraction is a symptom of poor resource management and gives greater credence to the participation of local communities in management of the water resources to which they are major beneficiaries.

The following summary conclusions can be made about the status of water development in the Sirimon river catchment:
The current state of development of river water abstractions in the region indicates the following spatial patterns:

(i) In terms of abstraction volumes, gravity pipeline systems have the largest share at 59% of total abstraction volumes. The are concentrated in the upper parts of the river reaches where steep foot slopes are to be found.
(ii) There are only four fixed pumped systems all but one serving relatively large-scale horticultural establishment. This is attributed to the high cost of pumping.
(iii) Portable pump systems predominate the river water abstraction scenario where water supply development targets individual small holder farmers for small scale horticultural irrigation and the regulation of water use is not very strict.
(iv) There are no canal (Furrow) abstractions. An existing furrow (Mworoga Project) has since been piped in an effort to reduce seepage losses during low flows.

This survey provides the basic information about river water use, the different stakeholders, the systems used to extract water from the rivers and the amount of river water available and used. It analysis the abstraction works in terms of design, legality and flow regulation and controlling mechanisms. All these are important aspects of river water off take management. The interaction between Water Department Personnel from Nyeri and Laikipia District and the local community has especially proved useful in enhancing the wider public awareness on the need and methods of dealing with water related assessment, problems and various aspects of water management.

There exists a number of water permit records for which it is not clear whether they are in use and the RWUA should analyze these records which are presented in the report with a view of providing a feedback that explains the status of these permits amongst its members. As seen in Appendix 1, there is varied cultivation activities at abstraction points and this information provides a starting point in efforts to harmonize the implementation of the Agricultural Act in terms of reserving an appropriate buffer zone between cultivation points and the river bank.

There has been an increasing demand for the formation and establishment of RWUA and their support structures both by the communities and water administrators to improve on water resources management in the catchment. Despite this, an effective RWUA has not been established mainly due to:

1. Existing conflicts resulting from current river water sharing.
2. Lack of adequate finances to mobilize users.

3. Disparity in interests among the users where some are seen to benefit more from the water resources.
4. Lack of clear guidelines on RWUA formation.

4.1 Recommendations for effective RWUAs

As the stakeholders in this catchment proceed with efforts to improve water resources management, it is important that various components that contribute towards effective RWUAs and improved river water resource management be identified. These are:

- Downstream communities must recognize that their river water resource is threatened. The downstream communities must be prepared to articulate their problems, be prepared to defend their rights to equal and fair access to the river water, and be prepared to take action by participating in the activities of the RWUA.
- Government officers, particularly local chiefs and water department staff, must be willing to co-operate with the RWUA. The government officers should be made aware that the function of the RWUA is to raise awareness of the river water users and to promote voluntary compliance with water permit restrictions. The RWUA can benefit by operating by consensus. This mechanism is very delicate and can easily be hijacked by authoritative officials.
- Decisions should be reached at “by consensus” rather than by vote where possible. The object of the RWUA is to get all members to comply with decisions, without having to resort to legal means to enforce them which is costly and time consuming.
- Communities should be reasonably stable, without excessive emigration, immigration or internal divisions. If a community is not stable, then that community has more problems in establishing and electing respected leadership.
- Active participation and support by the main water abstractors, be they community domestic water projects or private commercial irrigation enterprises.
- A reasonable sense of awareness and recognition by all the members that they can benefit from the association and that a common approach towards managing the resource is preferable to an open access approach which would lead to conflicts.
- Recognition of the types and distribution of water abstractors and adaptation of the RWUA organisation to ensure active participation and representation of the water users.

4.2 Conclusions

The evidence is out that all is not well in river water resource management; perennial rivers are becoming ephemeral with dire consequences in terms of time, money and conflicts especially to downstream communities. Kenya’s new Water Policy and The Water Bill 2002 provides policies and legislation aimed at improving river water management. One of the policies is to decentralize decision making to sub-basin and catchment institutions. At the individual river catchment level, one type of institution, namely the River Water Users Association, can be used as a mechanism of introducing community participation in the management of the river water resources. This would bring the principle stakeholders, who have a vested interest in sustainable management of their river resources, into the process of monitoring, allocating and managing the resource in a way that can compliment the official role of the Department of Water Resources or the Water Resource Management Authority.

The DWR (or the Water Resource Management Authority) is ultimately responsible for the river water management. DWR must continue to have responsibility and be able to discharge its duties to ensure sustainable river water resource management. However, DWR has a choice on whether and how to introduce community participation into the process. The RWUAs provide a suitable mechanism for enabling community participation in river water management that can compliment the role of the official authority.

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APPENDICES

APPENDIX 1 Information Of Permits, Riperian Vegetation At Point Of Water Use, The Observed River Bank Agricultural Activity and the Proportion of Flow Abstracted For The Sirimon River Water Abstractions

	Owner	Water Permit Number	Riperian Vegetation	Agricultural Activity	Proportion of Flow Abstracted (%)
1	Sirimon Wp	21743	Dense		53.34
2	Kangau wp	Not Known	Medium	tree nursery exists at the hydram site for community re-afforestation	2.17
3	Gakeu Wp (Gataro wp)	1182	Medium	some activity but not near river as banks steep	0.31
4	Home Grown Ltd	27763	Dense	None	25.31
5	Ambrose Mwangi	To Apply	Medium		0.13
6	Mugambi	To Apply	Medium	Abit close but no erosion.	0.20
7	Mr Karobia	Applied	Poor		0.13
8	MCK Kianjogu WP	Not Known	Dense		3.17
9	Kinyua Wa Nguku	Not Known	Poor		0.13
10	David N. Marete	To Apply	Poor		0.20
11	Josphat Gachagua	To Apply	Medium		0.13
12	Joseph Gikaria	Applied	Medium		0.07
13	Ndegwa Kiai	To Apply	Medium		0.27
14	Roise Wanjeri Waruka	To Apply	Medium		0.13
15	Daudi Mbogori	1867	Medium		0.27
16	Muriuki Karia	To Apply	Medium		0.81
17	Eliza	Applied	Poor	not near the river	0.03
18	Zacharia Waweru	To Apply	Medium	no activity near river	0.27
19	Maina Wamai	Applied	Poor		0.27
20	Monica Nyaruai	Applied	Medium		0.54
21	Mohammed Amin	2098	Medium		0.55
22	James Warui	To Apply	Medium	not close to river.	0.03
23	Munyi	Not Known	Poor	Adviced information to tell the owner about planting of trees.	5.37

24	Rosalid Wangui Makunu	To Apply	Medium		0.54
25	Godfrey Kariuki	To Apply	Medium		0.07
26	Mworoga Water Project	232112/ 13593	Medium	No Agricultural Activity	
27	Joseph Mwai	To Apply	Medium		0.13
28	Mr Karia	16262	Medium	Trees planted, not close to river.	0.54
29	Jerad Ngaca	Not Known	Medium	Trees planted, planting near river adviced against.	0.20
30	John Wachira	To Apply	Poor	Adviced to replant trees.	0.27
31	Johnson Mureithi	To Apply	Poor	Adviced to replant trees.	0.03
32	Munyi Aderson	26578	Poor		2.69
33	Gitonga Ndegwa	To Apply	Medium	close to river but adviced	0.13
34	Watene Mbugua	To Apply	Poor		0.20
36	Michael Muriithi	To Apply	Poor		0.20
36	John Watene	To Apply	Poor	Not close to river adviced on tree planting	0.27
37	John Watene	To Apply	Poor	not near river	0.40
38	John Njenga	To Apply	Poor	near river	0.13
39	Silas Njoroma	Applied	Poor	Not near river	0.27
40	Francis Muriuki	To Apply	Medium		0.07

Source (NRM3 DATABASE, 2003)